U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-261 595

Lake Darling, Renville and Ward Counties, North Dakota

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Oct 76

007057

PB 261 595

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT

ON

LAKE DARLING

RENVILLE AND WARD COUNTIES

NORTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 568

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 698-440

REPORT

ON

LAKE DARLING

RENVILLE AND WARD COUNTIES

NORTH DAKOTA

EPA REGION VIII

WORKING PAPER No. 568

WITH THE COOPERATION OF THE

NORTH DAKOTA STATE DEPARTMENT OF HEALTH

AND THE

NORTH DAKOTA NATIONAL GUARD

OCTOBER, 1976

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE	5. REPORT DATE
Report on Lake Darling, Renville and Ward Counties, North Dakota	Prepared October 1976
	6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Anonymous (National Eutrophication Survey Staff)	Working Paper # 568

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330	11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460	Final - 1974
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		37
	20. SECURITY CLASS *(This page)*	22. PRICE
		$4.00/3.00

EPA Form 2220-1 (9-73)

CONTENTS

	Page
Foreword	ii
List of North Dakota Study Lakes and Reservoirs	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	3
III. Lake Water Quality Summary	4
IV. Nutrient Loadings	8
V. Literature Reviewed	12
VI. Appendices	13

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the North Dakota State Department of Health for professional involvement, to the North Dakota National Guard for conducting the tributary sampling phase of the Survey, and to those North Dakota wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

Norman L. Peterson, Director, and the staff of the Division of Water Supply and Pollution Control of the Department of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

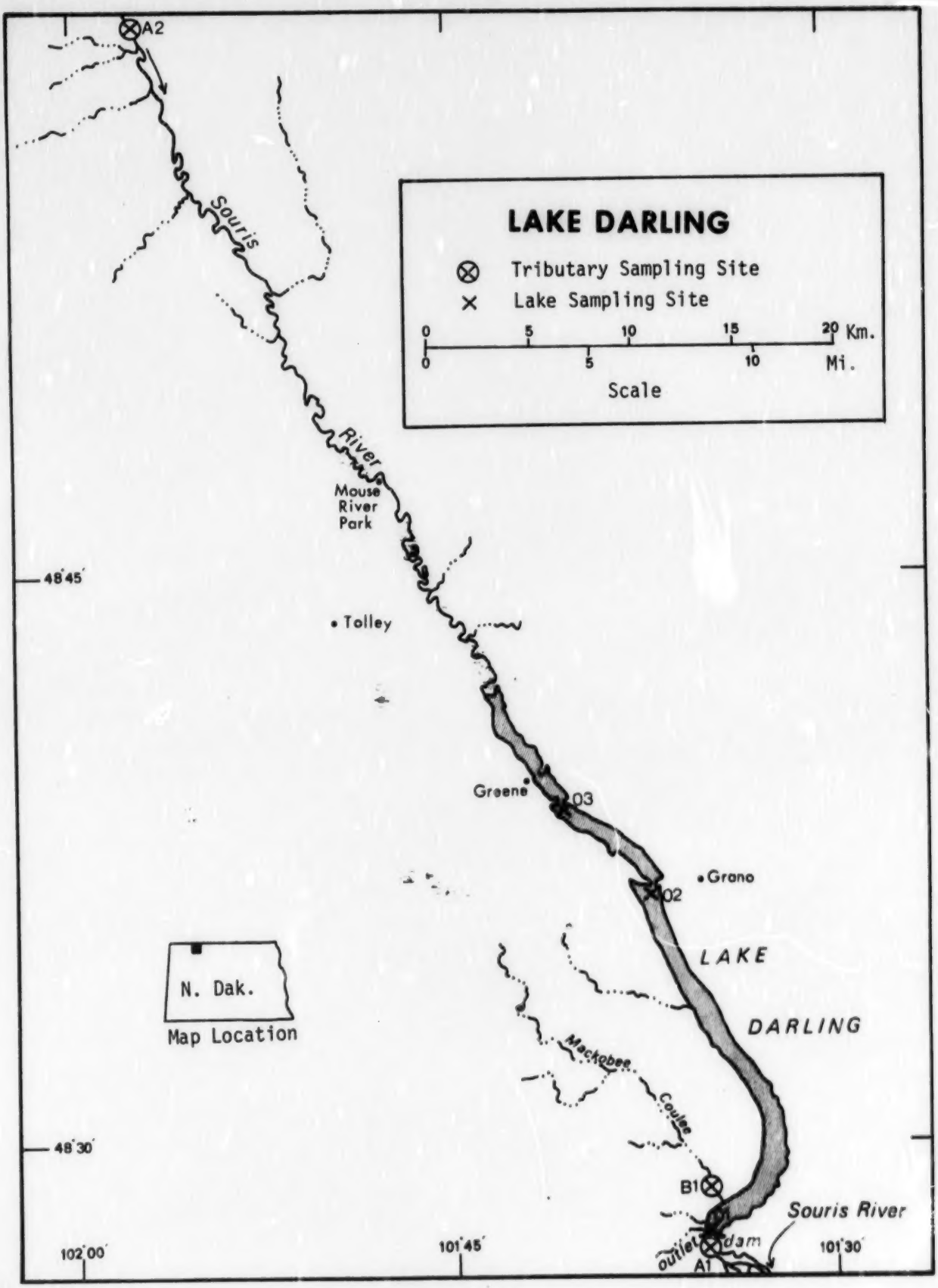
Major General LaClair A. Melhouse, the Adjutant General of North Dakota, and Project Officer Colonel Irvin M. Sande, who directed the volunteer efforts of the North Dakota National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF NORTH DAKOTA

NAME	COUNTY
Ashtabula	Barnes, Griggs
Audubon	McLean
Brush	McLean
Darling	Renville, Ward
Devils	Benson, Ramsey
Jamestown	Stutsman
LaMoure	LaMoure
Matejcek	Walsh
Metigoshe	Bottineau
Pelican	Bottineau
Sakakawea	Dunn, McKenzie, McLean, Mercer, Mountrail, Williams
Spiritwood	Stutsman
Sweet Briar	Morton
Whitman	Nelson, Walsh


LAKE DARLING
Tributary Sampling Site
Lake Sampling Site
0 5 10 15 20 Km.
0 5 10 Mi.
Scale
A2
Souris
River
Mouse
River
Park
48°45'
Tolley
Greene
03
Grano
02
LAKE
DARLING
N. Dak.
Map Location
Mackobee
Coulee
48°30'
B1
Souris River
outlet
dam
A1
102°00'
101°45'
101°30'

LAKE DARLING

STORET NO. 3804

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Lake Darling is eutrophic. It ranked last in overall trophic quality when the 14 North Dakota lakes sampled in 1974 were compared using a combination of six parameters*. Eleven of the lakes had less median total phosphorus, ten had less median dissolved orthophosphorus, eight had less median inorganic nitrogen, all of the others had less mean chlorophyll a, and ten had greater mean Secchi disc transparency.

Field limnologists noted algal blooms and surface scums at all sites during the July and September sampling periods.

B. Rate-Limiting Nutrient:

The algal assay results indicate the lake was nitrogen limited at the times the samples were taken (04/30/74 and 09/13/74). The lake data indicate nitrogen limitation in July as well.

C. Nutrient Controllability:

1. Point sources--No known domestic or industrial point sources impacted Lake Darling during the sampling year.

The present phosphorus loading of 0.48 $g/m^2/yr$ is 1.6 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11).

---

* See Appendix A.

2. Non-point sources--The phosphorus contribution of the Souris River accounted for 91% of the total load to Lake Darling during the sampling year. The ungaged drainage areas were estimated to have contributed 5.3% of the total load.

Land use in the Lake Darling drainage is mainly agriculture, and any reductions in nutrients would involve improved land-use practices. However, the phosphorus export rate of the Souris River was only 2 kg/km^2 during the sampling year (see page 10).

Nutrient loads from waterfowl are thought to be minimal since the lake proper is not prime waterfowl habitat as compared to neighboring refuge areas.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 40.06 kilometers^2.
2. Mean depth: 3.4 meters.
3. Maximum depth: 7.9 meters.
4. Volume: 136.204 x 10^6 m^3.
5. Mean hydraulic retention time: 1.4 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Souris River	7,873.6	3.081
Minor tributaries & immediate drainage -	503.8	0.193
Totals	8,377.4	3.274

2. Outlet -

Souris River	8,417.5**	3.150

C. Precipitation***:

1. Year of sampling: 49.4 centimeters.
2. Mean annual: 41.9 centimeters.

---

† Table of metric conversions--Appendix B.
†† Henegar, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Lake Darling was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two or more depths at two stations in April and three stations in July and September (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the April and September visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 4.3 meters at station 1, 5.5 meters at station 2, and 5.8 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR LAKE DARLING
STORET CODE 3804

PARAMETER	1ST SAMPLING (4/30/74) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (7/17/74) 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/13/74) 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	4.2 - 11.9	7.5	4.8	23.2 - 24.3	23.9	23.9	10.8 - 12.0	11.4	11.4
DISS OXY (MG/L)	8.0 - 8.8	8.3	8.2	3.4 - 9.6	7.0	7.8	6.8 - 10.4	9.0	9.6
CNDCTVY (MCROMO)	246. - 318.	278.	255.	540. - 1005.	794.	850.	445. - 597.	518.	511.
PH (STAND UNITS)	7.6 - 8.0	7.7	7.7	8.2 - 9.1	8.9	9.0	8.7 - 9.3	9.0	9.2
TOT ALK (MG/L)	86. - 114.	95.	89.	166. - 286.	226.	244.	190. - 288.	242.	258.
TOT P (MG/L)	0.123 - 0.143	0.133	0.132	0.265 - 0.414	0.327	0.304	0.172 - 0.359	0.266	0.263
ORTHO P (MG/L)	0.040 - 0.059	0.047	0.046	0.180 - 0.312	0.222	0.215	0.054 - 0.200	0.133	0.157
NO2+NO3 (MG/L)	0.340 - 0.450	0.408	0.430	0.040 - 0.080	0.063	0.070	0.020 - 0.160	0.074	0.040
AMMONIA (MG/L)	0.090 - 0.210	0.156	0.190	0.080 - 0.380	0.186	0.180	0.040 - 0.120	0.072	0.050
KJEL N (MG/L)	0.900 - 1.300	1.060	1.000	1.400 - 2.900	1.722	1.400	1.100 - 2.600	1.889	2.000
INORG N (MG/L)	0.430 - 0.660	0.564	0.630	0.120 - 0.460	0.249	0.240	0.070 - 0.280	0.147	0.090
TOTAL N (MG/L)	1.240 - 1.680	1.468	1.450	1.450 - 2.950	1.786	1.480	1.260 - 2.630	1.963	2.040
CHLRPYL A (UG/L)	6.9 - 19.3	13.1	13.1	11.7 - 69.4	36.1	27.3	13.1 - 262.4	115.3	70.5
SECCHI (METERS)	0.4 - 0.6	0.5	0.5	1.0 - 1.5	1.2	1.0	0.4 - 1.3	0.8	0.7

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/30/74	1. Cyclotella sp.	9,068
	2. Chroomonas sp.	585
	3. Cryptomonas sp.	553
	4. Chlamydomonas sp.	488
	5. Stephanodiscus sp.	130
	Other genera	259
	Total	11,083
07/17/74	1. Aphanizomenon sp.	3,959
	2. Phormidium sp.	2,672
	3. Chroococcus sp.	891
	4. Chroomonas sp.	247
	5. Flagellates	148
	Other genera	100
	Total	8,017
09/13/74	1. Aphanizomenon sp.	13,938
	2. Anabaena sp.	691
	3. Stephanodiscus sp.	479
	4. Chroomonas sp.	266
	5. Microcystis sp.	53
	Other genera	48
	Total	15,475

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/30/74	1	6.9
	2	19.3
	3	-
07/17/74	1	11.7
	2	69.4
	3	27.3
09/13/74	1	13.1
	2	70.5
	3	262.4

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. April sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.045	0.436	11.5
0.050 P	0.095	0.436	14.4
0.050 P + 1.0 N	0.095	1.436	29.4
1.0 N	0.045	1.436	18.0

b. September sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.120	0.403	16.1
0.050 P	0.170	0.403	18.6
0.050 P + 1.0 N	0.170	1.403	38.2
1.0 N	0.120	1.403	34.5

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Lake Darling was very high at the times the samples were collected (04/30/74 and 09/13/74).

There was a significant increase in yield when only nitrogen was added (the slight increase when only phosphorus was added is not considered significant). Based on these results, nitrogen limitation is indicated by both assays.

The lake data indicate nitrogen limitation at all sampling times; the mean inorganic nitrogen to orthophosphorus ratios were 12 to 1 or less, and nitrogen limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the North Dakota National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the North Dakota District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

No known wastewater treatment plants impacted Lake Darling during the sampling year.

A. Waste Sources:

1. Known municipal - None
2. Known industrial - None

---

* See Working Paper No. 175.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Souris River	17,380	91.0
b. Minor tributaries & immediate drainage (non-point load) -	1,010	5.3
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	700	3.7
Total	19,090	100.0

2. Outputs -

Lake outlet - Souris River 10,720

3. Net annual P accumulation - 8,370 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Souris River	190,060	77.5
b. Minor tributaries & immediate drainage (non-point load) -	12,090	4.9
c. Known municipal STP's - None	-	-
d. Septic tanks - None	-	-
e. Known industrial - None	-	-
f. Direct precipitation* -	43,250	17.6
Total	245,400	100.0

2. Outputs -

Lake outlet - Souris River 163,400

3. Net annual N accumulation - 82,000 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg $P/km^2/yr$	kg $N/km^2/yr$
Souris River	2	24

E. Mean Nutrient Concentrations in Ungaged Stream:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Mackobee Coulee	0.163	2.505

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.48	0.21	6.1	2.0

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Lake Darling:

"Dangerous" (eutrophic loading)	0.30
"Permissible" (oligotrophic loading)	0.15

V. LITERATURE REVIEWED

Henegar, Dale, 1975. Personal communication (lake morphometry). ND Game & Fish Dept., Bismarck.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
3801	LAKE ASHTABULA	0.260	0.160	472.250	40.892	10.600	0.170
3802	LAKE AUDUBON	0.087	0.220	446.222	11.322	11.000	0.015
3803	BRUSH LAKE	0.065	0.095	449.143	29.114	9.000	0.010
3804	LAKE DARLING	0.274	0.250	466.750	60.075	11.600	0.180
3805	DEVILS LAKE	0.630	0.140	449.333	38.508	14.600	0.469
3806	JAMESTOWN RESERVOIR	0.144	0.365	438.667	19.400	8.800	0.078
3807	LAKE LA MOURE	0.438	0.380	421.400	19.720	15.000	0.290
3808	MATEJCEK LAKE	0.228	0.440	475.167	2.683	14.400	0.179
3809	LAKE METIGOSHE	0.032	0.080	389.167	10.367	9.000	0.010
3811	PELICAN LAKE	0.034	0.070	364.500	10.950	12.800	0.006
3812	LAKE SAKAKAWEA (GARRISON	0.016	0.150	408.733	6.883	10.800	0.007
3813	SPIRIT WOOD LAKE	0.156	0.290	417.833	34.667	15.000	0.082
3814	SWEET BRIAR RESERVOIR	0.092	0.090	440.800	39.000	8.800	0.031
3815	WHITMAN LAKE	0.260	0.260	478.333	27.067	9.200	0.185

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3801	LAKE ASHTABULA	27 (3)	54 (7)	15 (2)	8 (1)	62 (8)	38 (5)	204
3802	LAKE AUDUBON	69 (9)	46 (6)	46 (6)	69 (9)	46 (6)	69 (9)	345
3803	BRUSH LAKE	77 (10)	77 (10)	38 (5)	38 (5)	81 (10)	81 (10)	392
3804	LAKE DARLING	15 (2)	38 (5)	23 (3)	0 (0)	38 (5)	23 (3)	137
3805	DEVILS LAKE	0 (0)	69 (9)	31 (4)	23 (3)	15 (2)	0 (0)	138
3806	JAMESTOWN RESERVOIR	54 (7)	15 (2)	62 (8)	62 (8)	96 (12)	54 (7)	343
3807	LAKE LA MOURE	8 (1)	8 (1)	69 (9)	54 (7)	4 (0)	8 (1)	151
3808	MATEJCEK LAKE	38 (5)	0 (0)	8 (1)	100 (13)	23 (3)	31 (4)	200
3809	LAKE METIGOSHE	92 (12)	92 (12)	92 (12)	85 (11)	81 (10)	81 (10)	523
3811	PELICAN LAKE	85 (11)	100 (13)	100 (13)	77 (10)	31 (4)	100 (13)	493
3812	LAKE SAKAKAWEA (GARRISON	100 (13)	62 (8)	85 (11)	92 (12)	54 (7)	92 (12)	485
3813	SPIRIT WOOD LAKE	46 (6)	23 (3)	77 (10)	31 (4)	4 (0)	46 (6)	227
3814	SWEET BRIAR RESERVOIR	62 (8)	85 (11)	54 (7)	15 (2)	96 (12)	62 (8)	374
3815	WHITMAN LAKE	27 (3)	31 (4)	0 (0)	46 (6)	69 (9)	15 (2)	188

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3809	LAKE METIGOSHE	523
2	3811	PELICAN LAKE	443
3	3812	LAKE SAKAKAWEA (GARRISON	485
4	3803	BRUSH LAKE	392
5	3814	SWEET BRIAR RESERVOIR	374
6	3802	LAKE AUDUBON	345
7	3806	JAMESTOWN RESERVOIR	343
8	3813	SPIRIT WOOD LAKE	227
9	3801	LAKE ASHTABULA	204
10	3808	MATEJCEK LAKE	200
11	3815	WHITMAN LAKE	188
12	3807	LAKE LA MOURE	151
13	3805	DEVILS LAKE	138
14	3804	LAKE DARLING	137

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR NORTH DAKOTA 03/16/76

LAKE CODE 3804 DARLING LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 8417.5

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3804A1	8417.5	0.82	0.71	1.64	11.36	10.59	4.19	3.26	1.53	1.08	0.76	0.93	0.82	3.15
3804A2	7873.6	0.062	0.068	3.483	17.670	8.212	3.540	2.350	0.623	0.340	0.278	0.252	0.113	3.081
3804ZZ	494.7	0.003	0.006	0.227	1.104	0.510	0.227	0.142	0.040	0.023	0.017	0.017	0.006	0.193

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 8417.5
SUM OF SUB-DRAINAGE AREAS = 8368.3
TOTAL FLOW IN = 39.31
TOTAL FLOW OUT = 37.69

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3804A1	9	74	1.487	22	1.699				
	10	74	0.861	21	0.850				
	11	74	0.929	18	0.934				
	12	74	0.864	20	0.856				
	1	75	0.702	21	0.510				
	2	75	0.541	21	0.481				
	3	75	1.354	18	1.104				
	4	75	22.257	5	1.812	20	15.801		
	5	75	120.120	7	121.196	18	146.115		
	6	75	32.225	22	33.980				
	7	75	6.683	22	3.483				
	8	75	2.118	20	2.690				
3804A2	9	74	0.283	22	0.144				
	10	74	0.229	21	0.266				
	11	74	0.241	18	0.235				
	12	74	0.167	20	0.176				
	1	75	0.161	21	0.156				
	2	75	0.144						
	3	75	0.164	18	0.184				
	4	75	35.085	5	0.170	20	48.705		
	5	75	114.796	7	183.493	18	110.719		
	6	75	19.539	23	14.413				
	7	75	3.710	22	2.265				
	8	75	1.104	20	0.878				
3804ZZ	9	74	0.017						
	10	74	0.014						
	11	74	0.014						
	12	74	0.014						
	1	75	0.014						
	2	75	0.014						
	3	75	0.028						
	4	75	2.832						
	5	75	2.265						
	6	75	1.274						
	7	75	0.708						
	8	75	0.283						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/16

380401
48 27 32.0 101 35 14.0 3
LAKE DARLING
38101 NORTH DAKOTA

11EPALES 2111202
0015 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	14 55	0000	4.8		24	255	7.60	88	0.200	1.100	0.430	0.042
	14 55	0005	4.8	8.2		246	7.60	86	0.190	1.000	0.440	0.040
	14 55	0011	4.2	8.0		251	8.00	89	0.210	1.000	0.450	0.046
74/07/17	11 25	0000	24.0	5.4	60	541	9.00	171	0.180	1.600	0.070	0.244
	11 25	0005	24.0	4.2		540	9.00	166	0.220	1.400	0.080	0.180
	11 25	0011	23.8	3.4		544	8.90	178	0.380	1.400	0.080	0.312
74/09/13	16 45	0000	12.0	6.8	50	447	8.67	191	0.120	1.400	0.150	0.200
	16 45	0010	11.9	7.0		446	8.67	190	0.120	1.400	0.160	0.194
	16 45	0014	11.9	7.2		445	8.69	193	0.110	1.100	0.160	0.181

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	14 55	0000	0.128	6.9	
	14 55	0005	0.123		
	14 55	0011	0.132		
74/07/17	11 25	0000	0.296	11.7	
	11 25	0005	0.336		
	11 25	0009			1.0
	11 25	0011	0.414		
74/09/13	16 45	0000	0.274	13.1	
	16 45	0002			50.0
	16 45	0008			5.0
	16 45	0010	0.274		
	16 45	0011			1.0
	16 45	0014	0.247		

JRET RETRIEVAL DATE 75/03/16

380402
48 36 45.0 101 37 02.0 3
LAKE DARLING
38075 NORTH DAKOTA

11EPALES 2111202
0012 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/04/30	15 20	0000	11.9		14	318	7.80	99	0.090	1.300	0.380	0.059
	15 20	0008	11.9	8.8		318	7.70	114	0.090	0.900	0.340	0.046
74/07/17	10 55	0000	24.3	8.6	39	866	9.10	256	0.100	2.900	0.050	0.202
	10 55	0005	23.9	7.8		850	9.00	244	0.150	1.800	0.070	0.215
	10 55	0013	23.5	6.4		822	9.00	254	0.200	1.400	0.070	0.229
74/09/13	15 20	0000	11.4	9.4	26	511	9.21	258	0.060	2.000	0.040	0.162
	15 20	0005	11.4	9.6		510	9.19	280	0.050	2.100	0.040	0.157
	15 20	0018	11.3	9.8		513	9.21	288	0.050	2.200	0.040	0.136

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/04/30	15 20	0000	0.143	19.3	
	15 20	0008	0.138		
74/07/17	10 55	0000	0.380	69.4	
	10 55	0005	0.299		1.0
	10 55	0006			
	10 55	0013	0.304		
74/09/13	15 20	0000	0.263	70.5	
	15 20	0002			50.0
	15 20	0004			5.0
	15 20	0005	0.359		
	15 20	0006			1.0
	15 20	0018	0.344		

23
GM

STORET RETRIEVAL DATE 76/03/16

380403
48 38 48.0 101 40 46.0 3
LAKE DARLING
38075 NORTH DAKOTA

11EPALES 2111202
0018 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
74/07/17	10	25 0000	24.2	8.8	39	1005	9.10	210	0.080	2.200	0.040	0.203
	10	25 0005	23.6	9.6		993	9.00	206	0.180	1.400	0.050	0.220
	10	25 0015	23.2	8.4		982	8.20	268	0.180	1.400	0.060	0.193
74/09/13	14	55 0000	11.2	10.4	14	595	9.29	250	0.050	1.900	0.020	0.055
	14	55 0009	10.9	10.4		595	9.17	262	0.050	2.300	0.030	0.056
	14	55 0019	10.8	10.2		597	9.23	264	0.040	2.600	0.030	0.054

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
74/07/17	10	25 0000	0.360	27.3	
	10	25 0005	0.285		
	10	25 0015	0.265		
74/09/13	14	55 0000	0.172	262.4	
	14	55 0001			50.0
	14	55 0003			5.0
	14	55 0004			1.0
	14	55 0009	0.258		
	14	55 0019	0.198		

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/03/18

3804A1
48 27 25.0 101 35 15.0 4
SOURIS RIVER
38055 7.5 CAMPIO NE
O/DARLING LAKE
BNK SAM OFF SEC RD 932 AT BASE OF DAM 83
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/09/22	09 30		0.208	1.600	0.080	0.130	0.160
74/10/21	11 05		0.152	1.400	0.035	0.035	0.080
74/11/18	10 30		0.048	1.600	0.045	0.015	0.030
74/12/20	09 30		0.040	1.500	0.045	0.030	0.030
75/01/21	09 20		0.040	1.100	0.120	0.020	0.030
75/02/21	09 30		0.040	1.700	0.103	0.016	0.030
75/04/05	10 25		0.005	2.200	0.100	0.015	0.040
75/04/20	10 45		0.210	1.250	0.200	0.035	0.060
75/05/07	11 30		0.525	1.200	0.125	0.040	0.090
75/05/18	10 00		0.410	1.400	0.080	0.050	0.090
75/06/22	11 00		0.015	1.200	0.035	0.045	0.110
75/07/22	10 20		0.025	1.550	0.025	0.280	0.340
75/08/20	09 20		0.020	4.400	0.090	0.310	0.540

JRET RETRIEVAL DATE 76/03/18

3804A2
48 59 24.0 101 57 28.0 4
SOURIS RIVER
38 RENVILLE CO MAP
T/DARLING LAKE
END OF 2NDARY RD 16.0 MI WNW OF SHERWOOD
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/09/22	12 10		0.020	1.300	0.010	0.045	0.120
74/10/21	12 45		0.248	0.950	0.040	0.020	0.080
74/11/18	13 50		0.024	1.500	0.045	0.015	0.050
74/12/20	11 00		0.264	1.700	0.128	0.025	0.090
75/04/20	12 20		0.870	2.000	0.155	0.100	0.270
75/05/07	12 15		0.500	1.400	0.030	0.045	0.130
75/05/18	12 00		0.340	1.250	0.060	0.125	0.200
75/06/23	13 10		0.360	1.780	0.040	0.105	0.245
75/07/22	11 45		0.260	1.450	0.050	0.090	0.170
75/08/20	12 00		0.470	1.800	0.075	0.070	0.270

STORET RETRIEVAL DATE 76/03/18

380481
48 28 36.0 101 54 52.0 4
MACKOBEE COULEE
38 7.5 CARPIO NE
T/DAHLING LAKE
SEC RD BRDG 1.5 MI N OF DAM 83
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
75/05/07	11 45		1.800	2.100	0.375	0.025	0.170
75/06/23	11 15		0.060	1.750	0.040	0.045	0.140
75/08/20	09 40		0.005	1.800	0.027	0.025	0.180